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14. ABSTRACT
The key deliverable in this award's statement of work is to "Develop a new program at Washington State University - the Spokane Sleep Research Initiative - to focus on the effects of sleep and sleep loss on human performance." As the Spokane Sleep Research Initiative grew, it was renamed the Sleep and Performance Research Center (SPRC).

Major findings published during the interval covered by this addendum (05/01/2010-04/30/2011) were 1) sleep loss effects are modulated by circadian rhythms; 2) sleep loss affects the performance of operational personnel with effects on both individual and group performance; 3) chronic sleep restriction degrades performance to a lesser degree than total sleep deprivation but recovery from chronic sleep restriction takes longer; 4) mathematical models can capture the homeostatic and circadian effects on performance and be useful in fatigue risk management; 5) basic science experimentation continues to be the mainstay in unraveling the neurobiology of sleep in particular the effects of local release of sleep regulatory substances in controlling local sleep; 6) over the reporting period, core faculty have continued to do original work and to integrate their work with the work of others through timely, thoughtful, and authoritative reviews

During the interval covered by this addendum (05/01/2010-04/30/2011), the Sleep and Performance Research Center 11 core faculty members have produced 62 publications (see References).

15. SUBJECT TERMS
Sleep, sleep loss, human performance

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Introduction

The Sleep and Performance Research Center (SPRC) conducts human and animal studies in laboratory and field settings in support of basic and applied sleep research at Washington State University (WSU). The SPRC focuses on understanding the brain organization of sleep in humans and animals and on using this understanding to link sleep, by way of the underlying neurobiology, to key indicators of performance, be they physiological, behavioral or cognitive. The research contributes to sustaining human productivity, safety, health, and well-being and may contribute to the understanding of the neurobiology of consciousness.

The SPRC core faculty members are:

Gregory Belenky, M.D., Research Professor, VCAPP, WSU Spokane (SPRC Director)

Christopher Davis, Ph.D., Assistant Research Professor, WWAMI, WSU Spokane

Lois James, Ph.D., Assistant Research Professor, Criminal Justice and Criminology, WSU Spokane

Levente Kapás, M.D., Ph.D., Associate Professor, VCAPP, WWAMI, WSU Spokane

Ilia Karatsoreos, Ph.D., Assistant Professor, VCAPP, WSU Pullman

James Krueger, Ph.D., Regents Professor, VCAPP, WWAMI, WSU Spokane

Jaak Panksepp, Ph.D., Professor, VCAPP, WSU Pullman

David Rector, Ph.D., Professor, VCAPP, WSU Pullman (left WSU in 2011)

Éva Szentirmai, M.D., Ph.D., Assistant Professor, VCAPP, WWAMI, WSU Spokane

Hans Van Dongen, Ph.D., Research Professor, VCAPP, WSU Spokane (SPRC Assistant Director)

Bryan Vila, Ph.D., Professor, Criminal Justice and Criminology, WSU Spokane

Jonathan Wisor, Ph.D., Associate Professor, VCAPP, WWAMI, WSU Spokane

The current eleven SPRC core faculty members are all involved in sleep research and their productivity is evidenced by their collective publications and extramural funding. SPRC core faculty members are internationally renowned for their scientific contributions, which have led to paradigm shifts in science and policy changes at the state and national levels.

Program of Research

Field Studies in Humans

Hobbs, Williamson, and Van Dongen (2010) found circadian rhythm effects on skilled maintenance performed by aviation mechanics.

Violanti and Vila (2010) found that when one police officer would fire others would fire too indicating what they termed "disinhibitory contagion."

Vila (2010) studied the effects of fatigue on police officer discretion and accountability.

Laboratory Studies in Humans

Banks et al. (2010) found that recovery from chronic sleep restriction may require a longer sleep period during one night or over several nights to effect a complete recovery.

Gander et al. (2010) found stable interindividual differences in slow wave sleep during both main sleep periods and naps.

Graumans et al. (2010) found time on task effects on reaction time in a simulated driving task.

Halverson et al. (2010) found that work shift affected strategy used to perform an orientation task.

Mollicone et al. (2010) found clear time of day effects on performance during chronic sleep restriction.

Tucker et al. (2010) found that acute sleep deprivation had varying effects depending on the component of executive functioning examined indicating that sleep deprivation effects on performance are not uniform or monolithic.

Van Dongen (2010) developed a mathematical model to predict sleep/wake behavior for use in fatigue risk management.

Laboratory Studies in Animals

Hallett et al. (2010) showed that individual whisker stimulation increased local expression of sleep regulating substances (nerve growth factor and interleukin-1 beta) in somatosensory cortex, providing support for the theory of local sleep. Hight et al. (2010) showed circadian rhythmicity in sleep regulating substances in both somatosensory and visual cortex, providing support for the theory of local sleep. Krueger et al. (2010) showed that purines and ATP affect sleep suggesting a

basis for the local, homeostatic (use dependent) drive for sleep. Thompson et al. (2010) found biological markers at the molecular level of sleep deprivation in the mouse brain.

Reviews

Belenky and Akerstedt (2010) introduced the field of occupational sleep medicine integrating sleep and performance research with clinical practice to improve work schedules, reduce errors, incidents, and accidents while detecting sleep disorders in the general population. Gander, Graeber, and Belenky (2010) reviewed the principles and practice of fatigue risk management. Goel, Van Dongen, and Dinges (2010) reviewed the circadian periodicity of alertness, performance, and sleepiness. Hursh and Van Dongen (2010) reviewed the role of mathematical models predicting performance from sleep wake history and time of day in fatigue risk management. Olofsen et al. (2010) reviewed the development of individualized performance predictions to replace the one size fits all models currently available. Rangan et al. (2010) review the integration of fatigue modeling in crew and rostering operations. Szentirmai and Kapas (2010) review the effects of hormones on sleep and of sleep in the regulation of hormones. Szentirmai, Kapas, and Krueger (2010) reviewed the interaction between sleep and feeding. Van Dongen and Hursh (2010) reviewed the role of fatigue in generating errors, incident, and accidents. Van Dongen et al. (2010) reviewed the evidence that sleep is a localized phenomenon. Vila and Samuels (2010) reviewed the importance of sleep for first responders and the military.

Key Research Accomplishments

- Sleep loss effects modulated by circadian rhythms affect the performance of operational personnel with effects on both individual and group performance
- Chronic sleep restriction degrades performance to a lesser degree than total sleep deprivation but recovery from chronic sleep restriction takes longer
- Mathematical models can capture the homeostatic and circadian effects on performance and be useful in fatigue risk management
- Basic science experimentation continues to be the mainstay in unraveling the neurobiology of sleep in particular the effects of local release of sleep regulatory substances in controlling local sleep
- Over the reporting period, core Sleep and Performance Research Center faculty have continued to integrate their work with the work of others through timely, thoughtful, and authoritative reviews.

Reportable Outcomes

- Sleep loss and adverse circadian phase degrade many aspects of human performance creating the conditions for errors, incidents, and accidents
- Mathematical models are useful in predicting performance in sleep loss and adverse circadian phase

- Studies in both humans and animals are necessary to unravel the neurobiology of sleep, sleepiness, alertness, and performance

Conclusions

Sleep, sleep loss, and performance are active areas of research with progress being made through field studies of humans, laboratory studies of humans and animals, field and laboratory studies of humans, and scholarly review of the existing scientific literature.

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